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Contents

Administrative Actions

During this project phase, Salam Sikder continued as the research student working on the investigation, under the supervision of Colin Thorne at the University of Nottingham. It was confirmed that Salam Sikder will work on the project full-time for the remaining months of the project – as specified in the project proposal.

Technical Work performed in this Reporting Period

Aim

The aim of this research is to compile a database of meander shifting observed in US rivers over periods of 30 to 60 years that can be used to estimate possible sediment yields due to bend movement. The database is based on an existing Transportation Research Board database, but with improved quality control and accuracy. The potential for using the database to make estimates of bank erosion sediment yield will be explored towards the end of the study.

Quality checking the data base

During this reporting period, the major effort on building a quality controlled database on meander bend migration was completed with final checks on the last few queries and questionable data points.

Statistical Analyses

The quality assured database that was supplied to Dr Lisa J Hubbard in the Coastal and Hydraulics Laboratory at the Waterways Experiment Station, ERDC, Vicksburg Mississippi at the end of the last reporting period has been analyzed statistically during the present reporting period.

Statistic evaluation and investigation of the quality assured database has initially focused on rivers and sites with Brice Type C morphologies (single-phase meandering, wider at bends, with point bars). Examination of the univariate distributions of key variables established that the preferred variables to be carried forward into the predictive analysis for bend migration rates are:

1. Bend radius – the minimum radius of curvature observed at the beginning of the monitoring period.
2. Channel width – the top width of the channel in the straight reach (crossing) approaching the meander bend at the beginning of the monitoring period.
3. Meander migration rate – the maximum shift in the position of the bend apex between consecutive air photographs.

These variables have been selected because their univariate distributions are, statistically, not significantly different from normal and because they provide a rational basis for use in predictive equations as they represent the geometry of the bend and the channel at the beginning of the monitoring period. Obviously, the radius and width at the end of the monitoring period would not be known in situations where meander migration is being predicted. Hence, it makes sense to use these values rather than time-averaged ones, in the statistical analysis.

The scatter of points in a bivariate plot of these variables has a distribution broadly similar to that observed by previous studies and describes a positively-skewed

distribution (Figure 1).

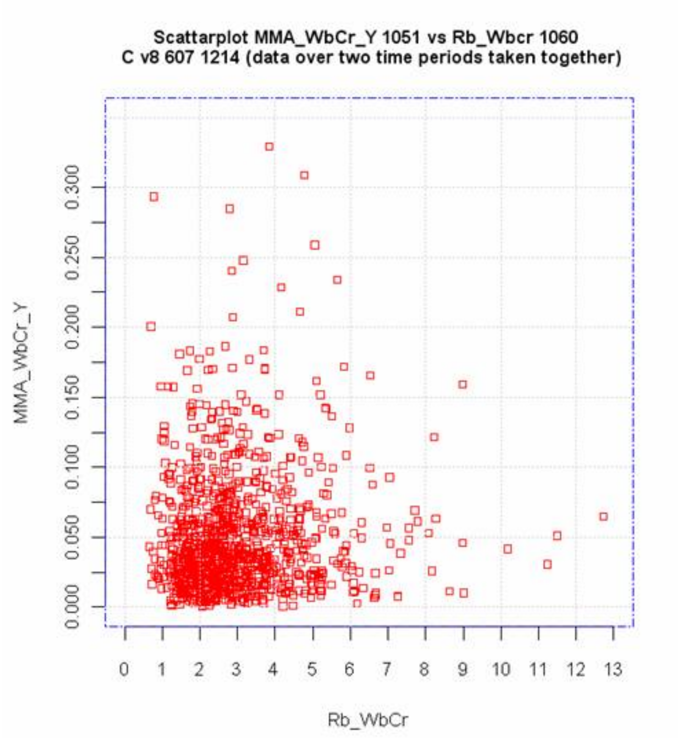

Figure 1. Scatter plot of data for all Brice Type-C bends in the cleaned up database.

However, it is apparent that the data base includes some outliers that plot away from the main data cloud and would not fall beneath the upper bound envelope curve typically found for this type of bivariate distribution by previous researchers (see for example, Knighton, 1998). Drawing a typical upper bound envelope curve onto Figure 1 shows 21 outliers (Figure 2) and omitting these points makes it much easier to define a data cloud that is similar to that observed in other studies (Figure 3).

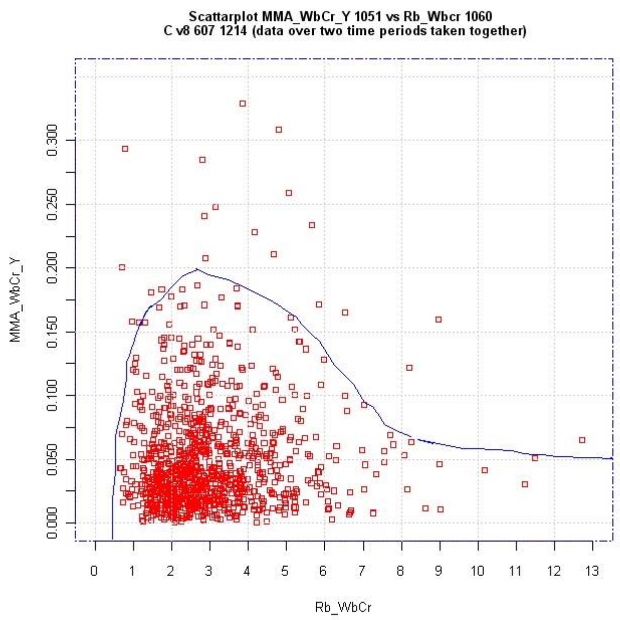

Figure 2. Scatter plot with typical upper bound envelope curve based on other studies of bend migration to identify outliers.

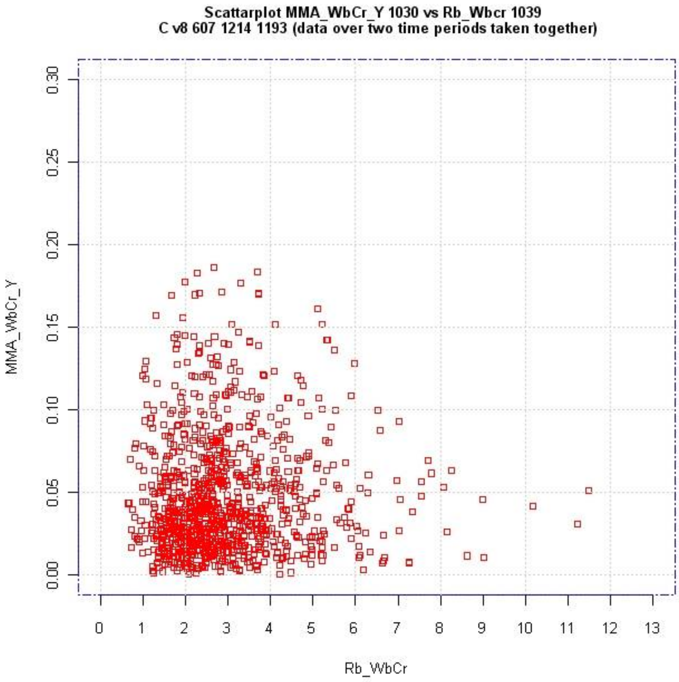

Figure 3. Database with extreme values removed until they can be verified by further investigation of the original TRB database and information in the Brice Collection at ERDC-WES.

The validity of the 21 outlying points is to be investigated further to decide definitively whether they should be excluded from further analysis. In the meantime, further analysis of the data will proceed along two tracks. The first will exclude the suspect data points (Figure 3). The second will examine the complete database, including points with extremely high migration rates that plot outside the realm of published, observed meander migration rates worldwide (Figure 1). Analysis the normality of the bivariate distributions in Figures 1 and 3 was investigated and it was established that the distribution is log-normal. As the statistical analysis of normal distributions is preferred, the probabilistic analysis was performed on logged, rather than arithmetic, data. The scatter plot for the log-log data is shown in Figure 4.

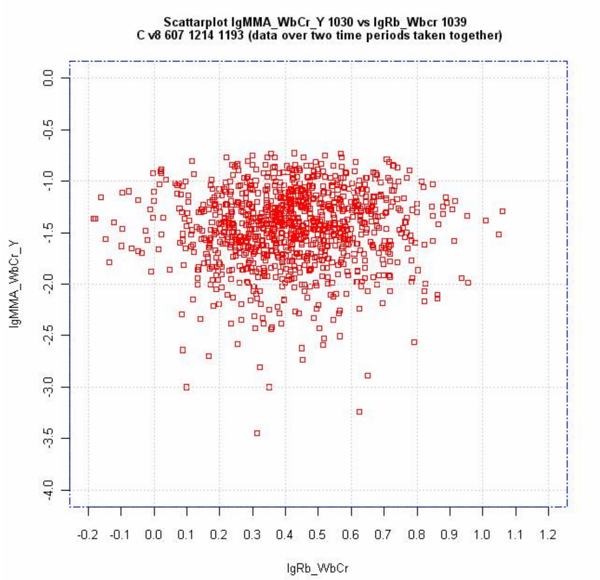

Figure 4. Scatter plot on log-log axes.

The bivariate probability density function for the log-data was fitted using an advanced statistical package 'r' which is available free for academic and scholarly research. The resulting distribution shows a single, distinct and almost symmetrical peak (Figures 5 and 6).

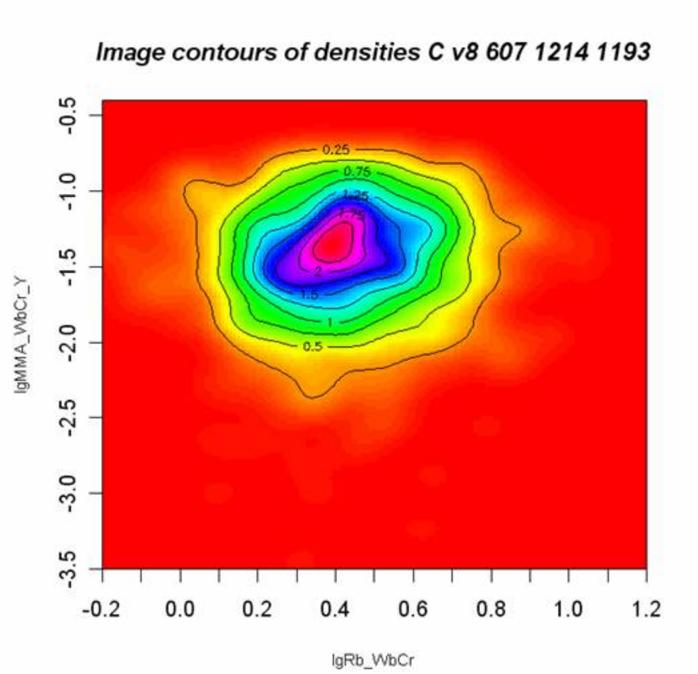

Figure 5. Density function plotted as the z-variable on a 2-dimensional plot with the same axes as in Figure 4.

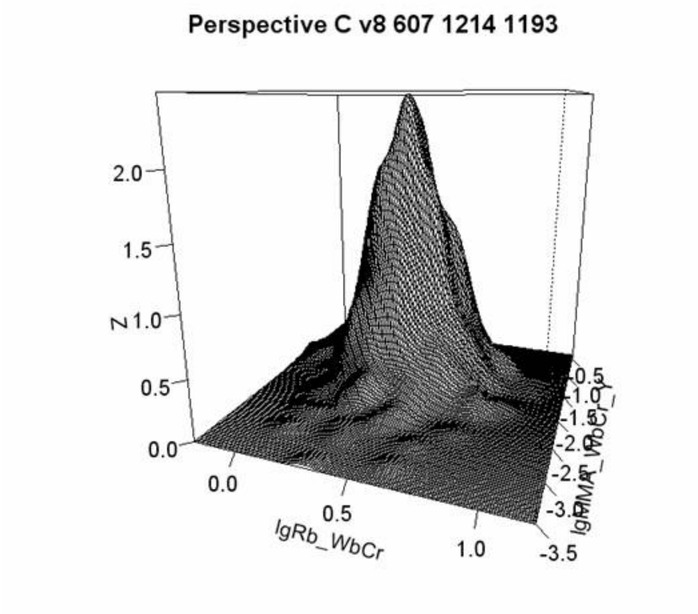

Figure 6. Density function plotted in 3-dimensions with density on the z-axis.

The next step was to investigate the conditional probabilities for specified values of R/w (the x variable). This was done by taking slices through the surface for the

bivariate probability density function for selected values of R/w over a range from 1 to 10.

The conditional probability density distribution for each value of R/w was then compared to a normal distribution having the same mean and variance. The two distributions for typical R/w values of are plotted alongside each other in Figure 7.

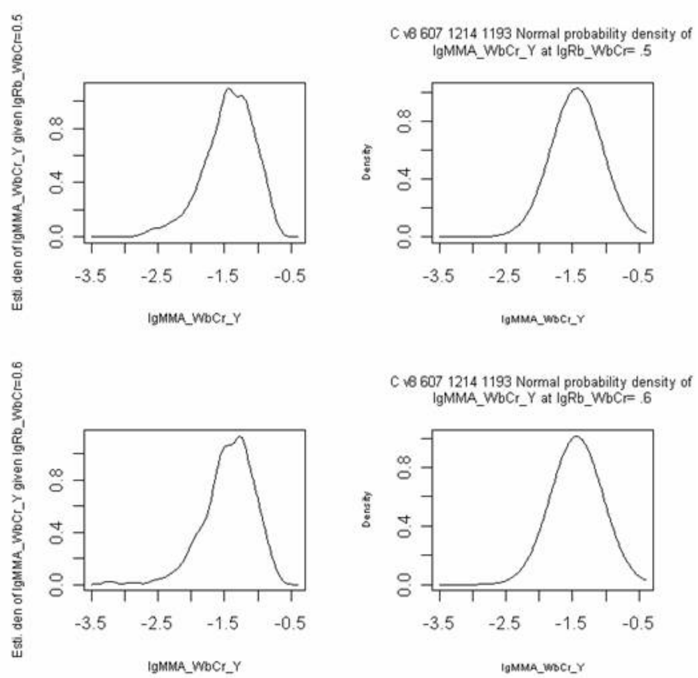

Figure 7. Conditional probability plots for typical values of R/w. The left plots show the density function fitted to the data. The right plots show a normal distribution with the same mean and variance.

Normality of these distributions means that it is straightforward to extract from them the mean annual meander migration rate for any specified probability of not being equaled or exceeded. This approach was used to determine meander migration rates corresponding to probabilities of not being equaled or exceeded of 50, 60, 75, 80, 90, 95, 97, 98 and 99%.

These curves are plotted onto the scatter graphs with log-log axes in Figure 8 and arithmetic axes in Figure 9.

The curves may be used to estimate the mean annual migration rate for a given R/w, with chance of this being not equaled of exceeded corresponding to the specified probability level.

Hence, to find the median (50%) migration rate, the 50% curve would be used. However, to be more conservative in terms of predicting the sediment yield due to bend migration, a higher probability, say 75%, might be used (corresponding to the upper quartile. In cases where it is required to predict the maximum sediment yield due to bend migration, the 99% curve could be used.

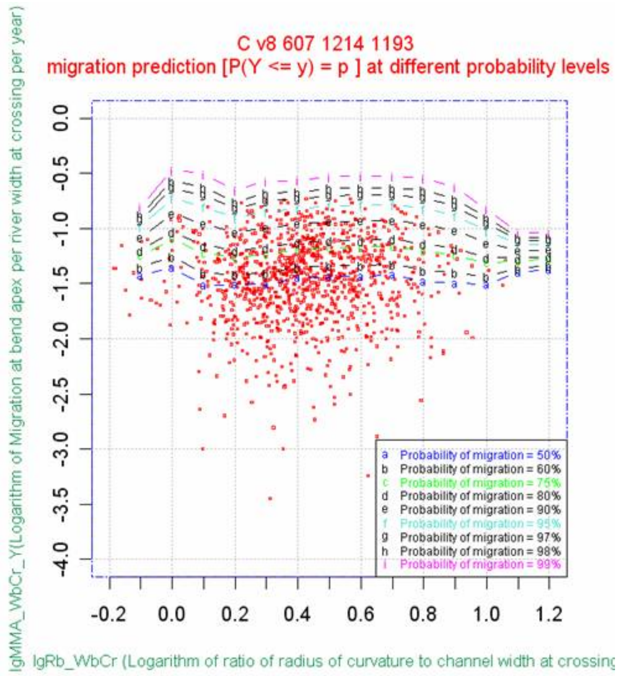

Figure 8. Scatter plot with probability curves for meander migration not to be equaled or exceeded on log-log axes.

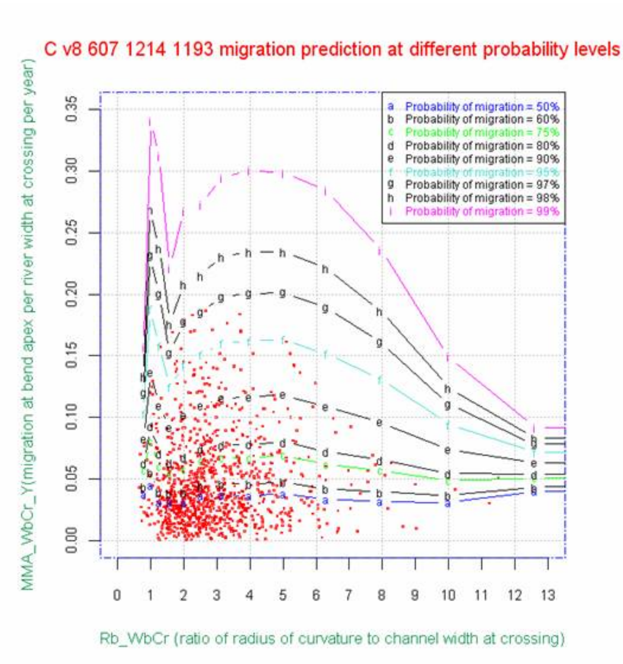

Figure 9. Scatter plot with probability curves for meander migration not to be equaled or exceeded on arithmetic axes.

The curves indicate that the median bend migration rate varies little with R/w and has an almost constant value of about 5% of the channel width per year. For more extreme shifting, the migration rate does vary with R/w. Bends with R/w in the range 3 to 5 have the high migration values, which can reach 30% of the channel width per year for a 99% probability of not being equaled or exceeded. Very short radius bends with R/w values ~1 also have the potential to shift very rapidly, with the 99% probability migration rate approaching 0.35.

Plan for next Reporting Period

During the next reporting period, work will be performed to undertake the third task specified in the proposal:

Task III. Estimating the bank erosion sediment yield
Explore the database to suggest suitable methods for estimating the height of the eroding bank and the average length of eroding bank line per river mile. These factors are required to convert the average bend shifting rate into an estimated bank erosion sediment yield for a river reach of user-specified length.

In this context, the work performed in Phase 2 will provide the basis for estimating bank sediment yield in the final phase of the study during the third reporting period, which is the final task:

Project variations

There have been no significant variations to the project during the reporting period.